76

THE ELECTRICAL DEPARTMENT OF THE CITY OF EDMUNDSTON

LOW HEAD HYDROELECTRIC DEVELOPMENT PROJECT

CREDA PROJECT # 2064

FEBRUARY 1985

REPORT PREPARED BY
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EDMUNDSTON, NB.

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Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

Conservation & Renewable
Energy Division
Energy Secretariat
P.O. Box 6000
Fredericton, N.B.
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Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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D I S C L A I M E R

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D E N I D E R E S P O N S A B I L I T E

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TABLE OF CONTENTS

Page No.

1.0 Executive Summary.....1

2.0 Introduction and Background.....3

3.0 General Description of the Demonstration.....5

4.0 Observations During Installation and Monitoring.....7

5.0 Cost/Benefit Analysis.....10

6.0 Conclusions.....14

7.0 Recommendations.....15

Appendices:

Appendix 1 - Information Transfer
Appendix 2 - Supporting Material

1.0 EXECUTIVE SUMMARY

There are only a few areas in the Province of New Brunswick like the City of Edmundston where electrical distribution systems are independently owned. The City of Edmundston Electrical Department is responsible for the distribution of electricity to its customers, the residents of the city. Although most of the electricity is purchased from the New Brunswick Power Commission, a small portion is generated by the City of Edmundston at the hydroelectric generating station it owns on the Green River, approximately thirteen miles north of Edmundston. The city has been operating this generating station for well over half a century.

In the early years when demand for electricity was minimal, output from the hydroelectric generating station was sufficient to meet the city's requirements. Over time electrical demand has increased tremendously, so that today the generating station supplies approximately 7% of electricity consumed in the City of Edmundston.

Throughout the existence of the Green River hydroelectric station, the City of Edmundston has carried out major improvements to increase the generating capacity of the station. For the last 5 to 10 years, the city had been considering additional hydroelectric generating units at the Green River station. The increasing costs of energy during the last decade

have given greater justification to the project.

After a thorough, positive feasibility study, the City of Edmundston initiated the low head hydro project in the Fall of 1982. The project was completed in the Fall of 1984. The project included the installation of two (2) additional one megawatt electric generating units at the Green River plant. Some major modifications were carried out on the power house, the transformer, the control system and the electricity supply transmission lines. The main objective of the project was to demonstrate the feasibility of upgrading, renovating and improving the electrical generating capacity of an old hydroelectric power plant.

Since start-up, in the Fall of 1984 to the present, under conditions of continuous power generation, it can be confirmed that the Demonstration Project has met with success. The project is, in fact, proving that it is feasible and practical to upgrade old low-head hydroelectric generation plants.

1.0 SOMMAIRE-RECOMMANDATION

Il n'existe que quelques endroits dans la province du Nouveau-Brunswick, comme à Edmundston, où le réseau de distribution d'électricité est exploité par un service indépendant. En effet, la Cité d'Edmundston possède son propre service d'électricité qui sert à distribuer l'électricité à ses abonnés, les résidents de la municipalité. Bien que la plus grande partie de l'électricité est achetée de la Commission d'énergie électrique du Nouveau-Brunswick, une petite partie provient de la centrale hydraulique municipale située sur la rivière Verte, à environ 13 milles au nord d'Edmundston. La municipalité exploite cette centrale électrique depuis un bon demi-siècle.

Dans les premières années, alors que la demande d'électricité était faible, la capacité de production de cette centrale était suffisante pour satisfaire les besoins de la municipalité. Avec le temps, cette demande a augmenté considérablement et aujourd'hui, la centrale ne comble qu'environ 7 % des besoins totaux à Edmundston.

Depuis que cette centrale existe, la Cité d'Edmundston a procédé à d'importants travaux d'amélioration pour augmenter sa capacité de production. Et au cours des 5 à 10 dernières années, la municipalité songeait à aménager de nouvelles installations à la centrale de la rivière Verte. Pendant ce temps, la hausse des coûts de l'énergie constituait une justificaiton encore plus grande de la réalisation de ce projet.

Suite à une étude de faisabilité approfondie et favorable, la municipalité entreprenait ce projet d'installatiors hydro-électrique à faible hauteur de charge à l'automne 1982. Les travaux furent achevés à l'automne 1984. Le projet comprenait l'aménagement de 2 (deux) nouvelles installation de production

d'électricité d'un mégawatt à la centrale de la rivière Verte, ainsi que quelques modifications importantes à la centrale même, au transformateur, au système de commande et aux lignesde transmission servant à distribuer l'électricité. Le principal objectif du projet était de démontrer la faisabilité de l'amélioration, de la rénovation et du perfectionnement d'une ancienne centrale hydro-électrique.

Depuis son exploitation, à l'automne 1984, et jusqu'à maintenant, dans des conditions de production continuelle d'électricité, ce projet de démonstration s'est révélé un succès. En fait, le projet a démontré qu'il est faisable et pratique de perfectionner les installations des anciennes centrales hydro-électriques à faible hauteur de charge.

2.0 INTRODUCTION AND BACKGROUND

a) General

The Green River hydroelectric generating station was not producing electricity to full capacity and hence not taking advantage of all the water that was available. This situation was corrected by the addition of two (2) one megawatt horizontal tube turbine generating units.

Nordic Consultants remain convinced this installation is the best alternative for increasing electrical generating capacity for the City of Edmundston.

b) Objectives

The Demonstration Project had the following objectives:

i) To demonstrate that the generating capacity of the station can economically be increased from 950 kW to approximately 3000 kW by using horizontal tube type turbines.

ii) To promote the feasibility of upgrading, renovating and improving the electrical generating capacity of old hydroelectric power plants.

iii) To demonstrate better control of Electrical Department operating costs. The addition of these two (2) generating units represents an estimated increase in revenue for the Electrical Department of approximately $240,000 in the first year of operation.

c) **Savings**

The new units have been in operation for only a few months and the amount of savings generated has not yet been compiled. The exact amount of savings will be apparent after a full year of operation.

The amount of savings will depend greatly upon spring run-off and the number of kilowatt-hours generated during this period. Nevertheless, from studying the records that were accumulated over the years for the runoff, a saving of approximately $200,000 is anticipated in electricity costs for the first year of operation. Enclosed in the Cost/Benefit Analysis is a table showing anticipated savings for the next few years.

d) **Future Market**

Possible future applications of this project have not been identified as such, however, it is suggested that the Province of New Brunswick consider development of new low-head hydroelectric generating plants, public or private, to reduce dependence on non-renewable energy sources, at a very feasible cost.

3.0 DESCRIPTION OF DEMONSTRATION

a) Introduction

As mentioned previously, the City of Edmundston, through its Electrical Department owns and operates a hydroelectric generating station located on the Green River. Prior to the implementation of the project, the station consisted of a vertical turbine-generator unit producing approximately 950 kW.

The potential electricity production of this station was higher than 950 KW if the amount of water that was wasted during the year is taken into account. In this critical time of high energy costs it was felt that the city should produce all the electricity it could in order to reduce purchases of electrical power.

b) Proposed Project and Description

Previously 6 to 7 percent of the city's annual requirement was generated at the Green River Station. With the implementation of the project production was increased to approximately 11%. To accomplish this, two (2) tube turbines and generators were installed in the old power house adjacent to the existing power house which shelters the vertical unit. The project included modifications to the intake, power house and tailrace. The old power house was enlarged and renovated.

A new transformer (5,000 kVA) was installed, and an existing transformer had to be rewound. The transmission line was also upgraded.

The two tube turbines that were installed for this project were manufactured by Allis-Chalmers in their Lachine, Quebec plant. The two units each operate under a net head of water of approximately 20 feet and a flowrate of approximately 750 cubic feet per second.

As mentioned above, through this installation the City of Edmundston has increased its generating capacity to 11% and at the same time reduced proportionately its electrical purchases.

c) **Sketches**

You will find enclosed in Appendix II sketches of the installation and a pamphlet giving pertinent information on the turbines.

4.0 OBSERVATIONS DURING INSTALLATION AND MONITORING

a) Installation

The actual construction phase of this project lasted over two years. The work schedule that was established in the planning stage was followed closely. Below are some comments for each stage of the Project.

i) First stage of the construction involved demolition of the existing power house. It was executed without any major problems except for drainage facilities which were installed to minimize water seepage through the intake and south-end walls.

ii) Second stage of the construction consisted of site preparation involving rock mass excavation. This stage of work was delayed because clearance requirements for the turbines inside the building were revised requiring more rock excavation at the tailrace.

iii) Third stage involved construction of the new power house itself. This stage was delayed because of the winter weather which required installation of temporary shelter and heating for proper pouring of concrete and curing. Secondly, a fire broke out a few hours after the new intake wall had been freshly poured. Because the fire destroyed three quarters of the wall, the intake wall had to be removed and a new

one had to be constructed.

iv) Fourth stage of the construction involved installation of the units and pouring the concrete to the units. This stage was carried out without any major interruptions except for some drainage problems which still existed. Drainage problems have persisted throughout the project.

v) Fifth stage consisted of electrical installations and successful start-up of the system. The electrical installation was delayed somewhat while the supplier clarified minor ambiguities on the electrical drawings. During the start-up a slight knocking from inside one of the operating units was quickly rectified by the installation contractor.

b) **Monitoring**

The monitoring, as was proposed consisted of comparisons between the actual electrical output and the theoretical output of the units.

The actual output of the units was monitored constantly from their electrical control panels beginning with the start-up in late Fall, 1984. At the present time, both units perform much better than expected. In fact, the units produce an average of 1100 to 1150 kW of electricity,

100 - 150 kW beyond their rated capacity. This part of the monitoring is being carried out successfully.

The second part of the monitoring, which deals with calculation of the theoretical output of the units, still has to be accomplished. In fact, this part will not be carried out until Spring, 1985, when the difference in elevation between the headpond and tailrace water levels and, also, the amount of water running through the units will be calculated with the actual output.

As was discussed and agreed upon with representatives from the Energy Secretariat, a complete monitoring report will be submitted upon completion of the second part of the monitoring following the 1985 Spring runoff.

5.0 COST/BENEFIT ANALYSIS

a) Cost

You will find enclosed a breakdown of the costs incurred for this project. The manpower costs involved for the construction of the power house are much higher than estimated. This may be attributed to an attempt by the City of Edmundston, in cooperation with Canada Manpower, to create job opportunities for the unemployed. Because of the inexperienced personnel hired, the amount of manpower required to complete the work exceeded estimated amounts.

Also a good part of the excavation work had to be performed by hand labour instead of by excavating equipment, hence increasing labour costs.

b) Sources of Financing

The project costs have been financed through contributions from the following agencies:

i)	Energy Secretariat/Energy, Mines and Resources	$ 210,000
ii)	Job Creation Programs (approx.)	800,000
iii)	Edmundston Electrical Dept.	2,652,108
	TOTAL	$3,662,108

COST ESTIMATES

CITY OF EDMUNDSTON

MODIFICATION TO EXISTING HYDROELECTRIC POWER HOUSE

ITEM		DESCRIPTION	COST	TOTAL
A	1.	Demolition	$ 165,445.94	$ 165,445.94
	2.	Site Preparation	381,878.34	381,878.34
	3.	Construction	1,015,990.60	1,015,990.60
		Sub total "A"		$1,563,314.88
		Engineering		82,393.32
B	1a.	Turbine-Generator Unit #1 (1000 kW)	859,200.00	
	b.	Field Service 150 Calendar Days	60,000.00	
	2a.	Turbine-Generator Unit #2 (1000 kW)	759,200.00	
	b.	Field Service 60 Calendar Days	24,000.00	
	3.	New 500 kVA Power Transformer	150,000.00	
	4.	Cost to Rewind Existing Transformer	90,000.00	
	5.	Cost to Revamp Transmission Line	64,000.00	
		Sub Total "B"		$2,006,400.00
C	1.	Performance Monitoring System	5,000.00	
	2.	Information Transfer	2,500.00	
	3.	Final Report	2,500.00	
		Sub Total "C"		$ 10,000.00
		TOTAL		$3,662,108.20

c) **Cost/Benefit Analysis**

Cost/Benefit Analysis includes capitalization costs of the project as summarized in the preceeding cost breakdown. No additional costs were foreseen. No increase in operational costs were planned since the additional turbines were to be operated through the existing control system by the regular operators.

Also included on the following page is a projected breakdown for the next five (5) years of money saved based on kWh and kW (demand) that will not have to be purchased from N.B. Power. Further projections of these annual savings at a rate of 5% increase each year reveals that it will take approximately 13.5 years to payback capitalization costs. Over that period of time approximately $3,662,108 worth of savings will be generated.

This payback period is believed to be very reasonable given the size of the project. The installation will in fact have a useful life of at least 40-50 years, and normally the payback period for a project of such a long lifespan is much greater than 13.5 years.

Throughout these calculations it has been assumed that the Electrical Department was financing 100% of the costs, which was not the case.

PROJECTED GENERATION AND MONETARY SAVINGS

DESCRIPTION	1985	1986	1987	1988	1989
1. Electricity Bought from NB Power					
a) kW·h	85 726 800	85 726 800	85 726 800	85 726 800	85 726 800
b) kW (Demand)	180 667	180 667	180 667	180 667	180 667
2. Cost of Electricity ($)	3 666 901	3 850 246	4 042 758	4 244 896	4 457 141
3. Electricity bought once the renewable energy source is installed					
a) kW·h	84 448 713	84 448 713	84 448 713	84 448 713	84 448 713
b) kW (Demand)	157 342	157 342	157 342	157 342	157 342
4. Reduction in Electricity bought					
a) kW·h	1 278 087	1 278 087	1 278 087	1 278 087	1 278 087
b) kW (Demand)	23 325	23 325	23 325	23 325	23 325
5. Reduction in Cost ($)	194 990	204 740	214 977	225 726	237 012

NOTE: 1. Cost for a kW·h of $0.0281 is for 1983. Assume same cost in 1985, then a yearly increase of 5%.

2. Assume the same thing for the kW (demand), at $6.81 /kW in 1985.

3. The cost of electricity both from NB Power and the cost saved for that produced were calculated using these unit prices.

6.0 CONCLUSIONS

This Demonstration Project was a very interesting and challenging one. It was an interesting project in the sense that it was unique: not a project that one has the privilege of participating in every year, maybe not even every ten years. It was challenging because it demonstrated for the first time in New Brunswick that this type of project could be accomplished successfully. Everyone involved in the project had something to be proud of.

The overall objectives of the project were met and it has been demonstrated successfully that a hydroelectric power plant over 50 years old can be renovated, given new life and used to its full potential very efficiently by the installation of horizontal tube turbines.

Much knowledge and experience has been gained from the realization of this particular project and most certainly this knowledge and experience could be utilized on similar projects in New Brunswick.

The clientele for such a project is limited, considering the project size and the high capitalization costs involved. Nevertheless, it is felt that there is a potential in New Brunswick for similar projects and that the Province should certainly look into these possibilities and inventory the most suitable ones for future action.

7.0 RECOMMENDATIONS

Experience acquired from this project has motivated a few recommendations:

a) Good planning is a must before initiating any project, such as this one. It is imperative that all aspects be studied, the technical-engineering aspect, materials and manpower procurement, costs, benefits and hence economic feasibility.

b) The construction phase is a crucial one. The schedule has to be followed very strictly. Chances are that the elements, such as Winter cold, Spring runoff, Summer heat will have to be taken into account in order to avoid delays or tight scheduling. It is very easy to over-run the project costs. Very rigid cost control has to be maintained.

c) The start-up phase is also very important. Make sure that everybody concerned with the start-up is available to trouble-shoot at this time. The service should be specified as part of the purchase and installation costs.

d) Existing and even abandoned hydroelectric generation plants should be investigated for possible upgrading since this would have a minimal effect on the environment.

e) A serious look should be taken by the Province and N.B. Power to promote small hydroelectric generation plants and create incentives for their implementation as has occurred in some other Provinces.

APPENDICES

APPENDIX I

INFORMATION TRANSFER

This section relates to the Information Transfer aspect of the project. Much publicity was given to this Demonstration Project. Without being limited to the following, the information transfer material listed below is available from the promoter of the project:

a) A slide presentation

b) A set of pictures of the project

The Electrical Department will hold an open-house in Spring, 1985 for public acknowledgement of the project. An official opening of the new installation, with suitable publicity, is also planned.

During the 2 years of construction many visitors were received at the site. As well, private visits for small groups have already been made.

Publicity for the project has been adequate up to this time, both Nordic Consultants and the City of Edmundston look forward to more opportunities in which they can inform others about this interesting project.

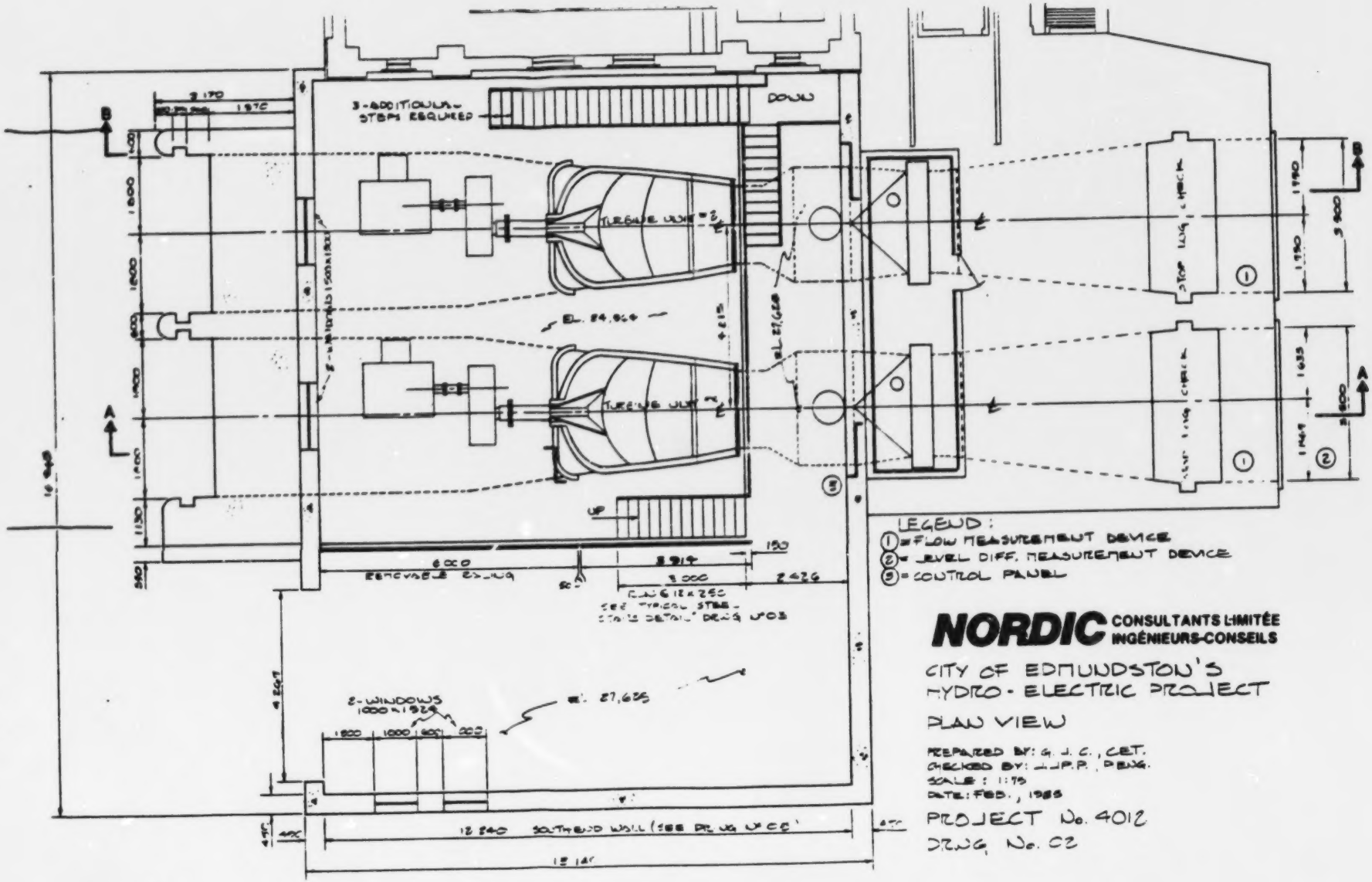
APPENDIX II

a) Site Plan

b) Plan view of the installation

c) A section view

d) A pamphlet for the tube turbine as made available by Allis-Chalmers.



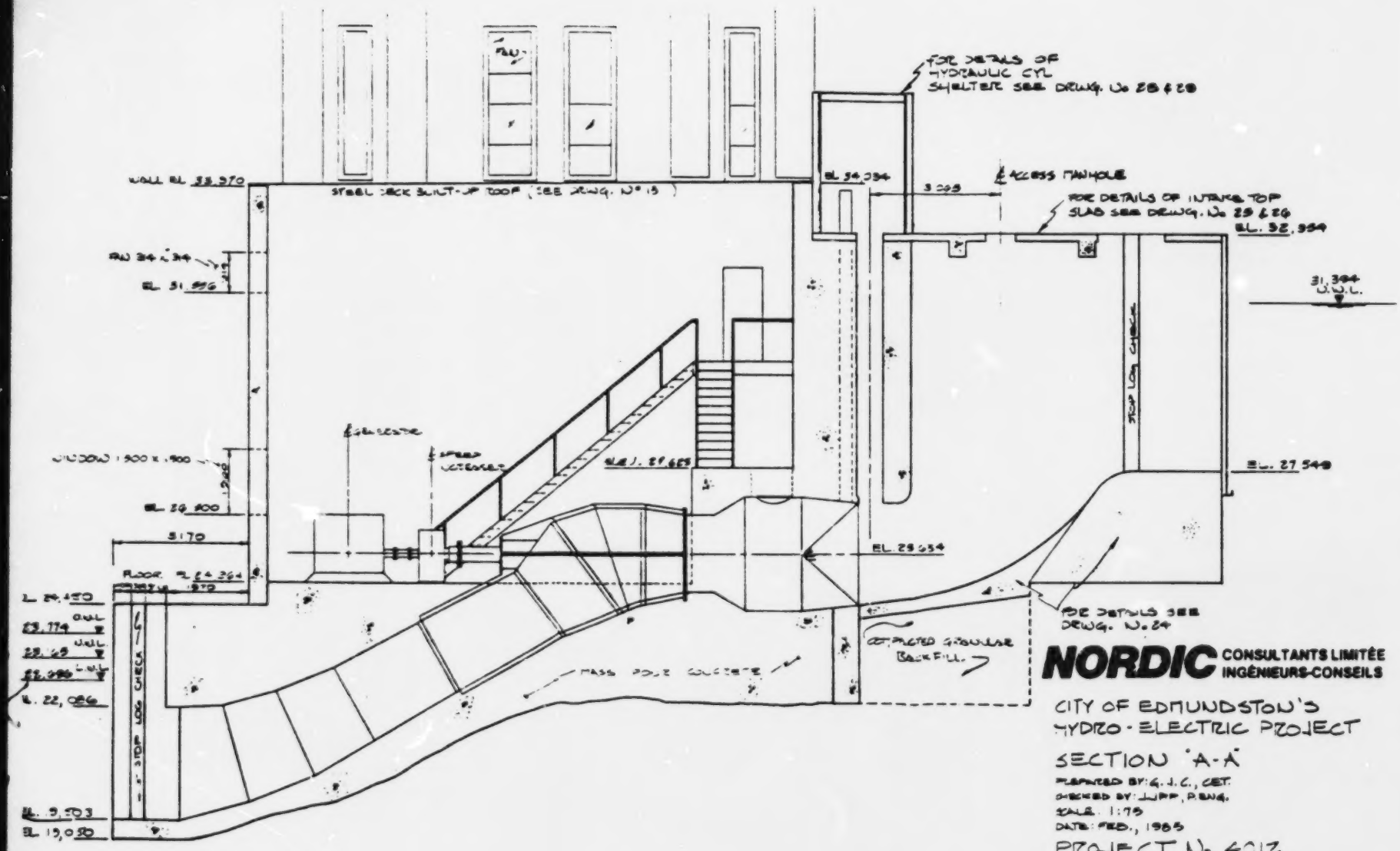
NORDIC CONSULTANTS LIMITÉE INGÉNIEURS-CONSEILS

CITY OF EDMUNDSTON'S
HYDRO-ELECTRIC PROJECT

PLAN VIEW

PREPARED BY: G. J. C., C.E.T.
CHECKED BY: J.J.P.P., P.ENG.
SCALE : 1:75
DATE: FEB., 1985

PROJECT No. 4012
DRWG. No. C2

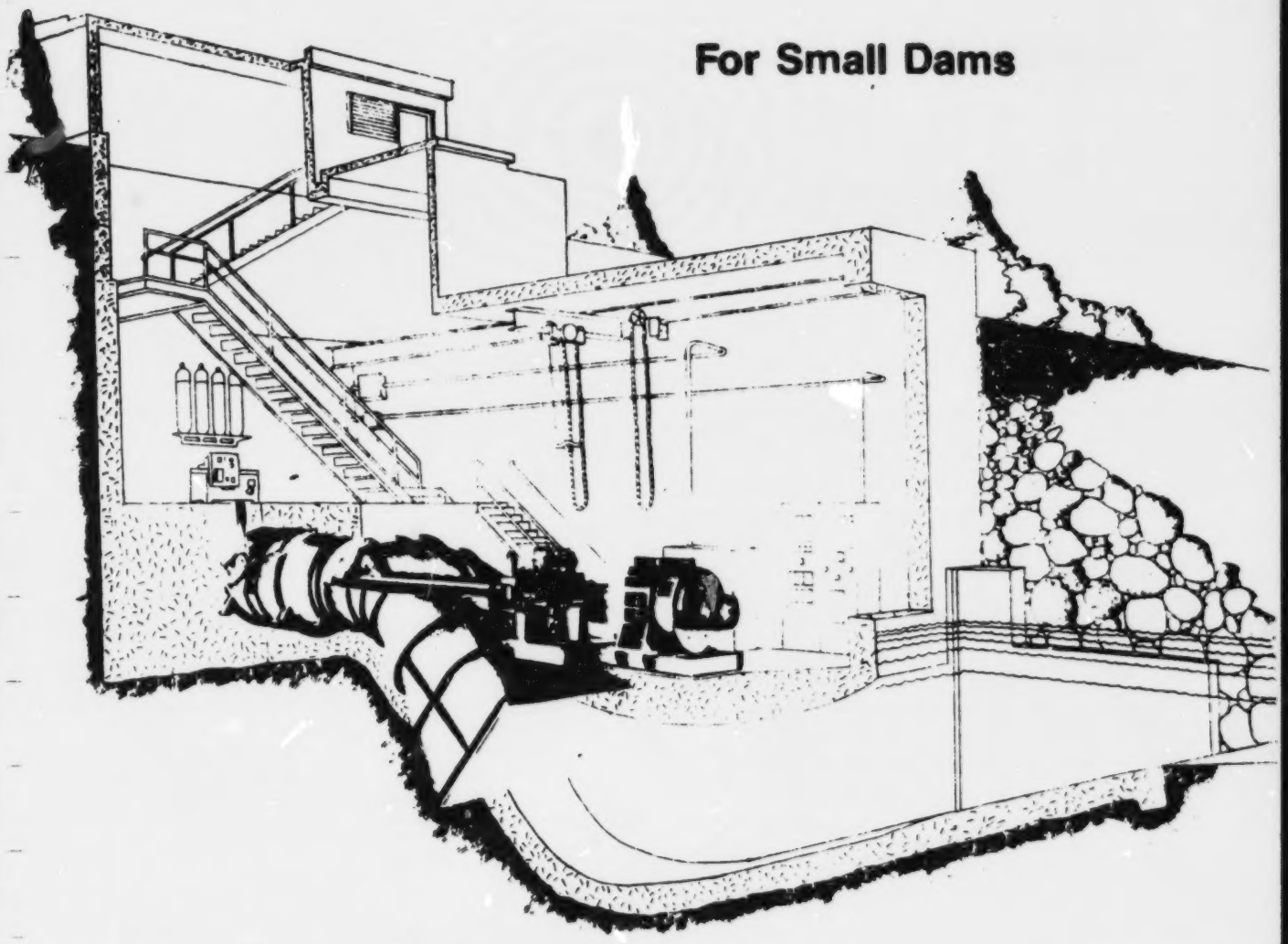


NORDIC CONSULTANTS LIMITÉE INGÉNIEURS-CONSEILS

CITY OF EDMUNDSTON'S
HYDRO-ELECTRIC PROJECT

SECTION "A-A"

PREPARED BY: G. J. C., CET.
CHECKED BY: J. P. P., P. ENG.
SCALE: 1:75
DATE: FEB., 1985
PROJECT No. 4012



For Small Dams

standardized
HYDROELECTRIC GENERATING UNITS

ALLIS-CHALMERS

Allis-Chalmers standardized hydroelectric units minimize custom engineering and use readily available standard commercial components to reduce project costs and total time. Projects can proceed from licensing to power production in nine to twelve months. Standard *TUBE* turbine packages in ten sizes — up to 5000 KW for heads to 50 ft., are adaptable for upgrading existing low-head plants, for making previously uneconomic sites attractive or for new power installations. And, they're backed by the experience of the foremost hydro-turbine manufacturer in the world — Allis-Chalmers.

Standardized Hydroelectric Generating Units an energy idea whose time has come

The need to use available renewable resources is readily apparent. With the trend of increasing oil prices and accelerated inflation, many previously uneconomical hydroelectric generating sites are now economical. It is in the national interest to develop such renewable energy resources as rapidly as possible. A significant amount of hydropower, particularly at existing dams, is readily developable and the technology for economical development is available.

THE [illegible]

Standardized, coordinated unit designs covering a wide range of heads and flows are available from Allis-Chalmers to permit economical development of the many existing or new small dams. These ten unit sizes facilitate economical redevelopment where the hydraulic energy of the water is presently not recovered, or where more modern generating units can economically increase the amount of power generated.

[illegible]S OF STANDARDIZATION

In the past, each turbine-generator unit was custom-designed to meet the hydraulic conditions at an individual site. Modern pre-designed TUBE turbines provide predictable, reliable installations at a lower cost per kilowatt.

[illegible] of standardization include:

- Spreads the design cost over multiple units.
- Obtains economies of scale in manufacturing.
- Utilizes commercially available components.
- Eliminates respecifying individual components.
- Simplifies feasibility studies.
- Facilitates quicker delivery.
- Simplifies purchasing for customers.

By standardizing the TUBE turbine, pre-engineering the equipment selection, employing experienced consulting engineers and keeping construction extras to a minimum, low head sites can be built fast and competitive with other energy sources.

The TUBE turbine units are extremely adaptable to various site conditions and can make previously uneconomical sites attractive. TUBE turbines are propeller-type units which provide the highest possible operating speed and the maximum capacity for a given size. The powerhouse structure can therefore be substantially reduced in area and height. The need for deep foundations is minimized, thus reducing excavation and other civil construction costs.

The building can more readily be blended into the dam and its surroundings. It may also be located underground or within the dam. The standard TUBE turbine concept permits maximum flexibility in arrangement and operating characteristics. Unit spacing, for example, is only two-thirds of a conventional vertical turbine for the same head and turbine output.

[illegible]ORMATION

Upgrading and or enlarging older low-head power plants with new modern standardized TUBE turbine units is a very economical means of adding significantly to our national energy supply. Allis-Chalmers standard TUBE turbine units are designed to be utilized in existing waterways and powerhouses with a minimum of new civil construction. The ten units ranging in output from 60 to 6,000 kilowatts, are extremely adaptable for retro-fitting low-head power plants. They can be arranged with the shafts either vertical or horizontal. The horizontal shaft arrangement generally permits installing more capacity within a given space as compared to the vertical arrangement. The vertical arrangement can reduce the length of a powerhouse and facilitates locating the generator well above flood water elevations.

EXPERIENCE

Since 1950, more than thirty TUBE turbine units have been designed and manufactured with runner sizes as small as 750 mm (30") in diameter, and as large as 8 m (315") in diameter, having heads as high as 15 m (50'), and outputs as great as 30 MW (42,400 HP).

These units include:

- Induction or synchronous generators.
- Black start capabilities with governor for frequency control.
- Automatic control from headwater or tailwater level.
- Station control, remote and local.
- Full Kaplan units, or units with only adjustable blades or fixed position blades.
- Direct driven generators or units having speed increasers with high speed generators.

The applications include:

- Additions to existing powerhouses.
- Replacement of old horizontal draft chest units.
- Maintenance of minimum flow requirements.
- Irrigation flow control.

The Purchasers include:

- Investor-owned power companies.
- Municipal utilities.
- Paper companies.
- Irrigation districts.
- Government agencies.

Sizing Criteria

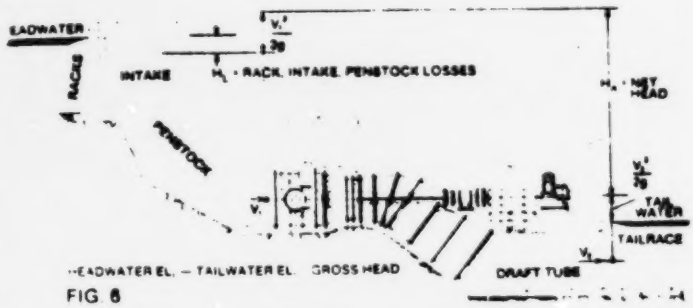


FIG. 6

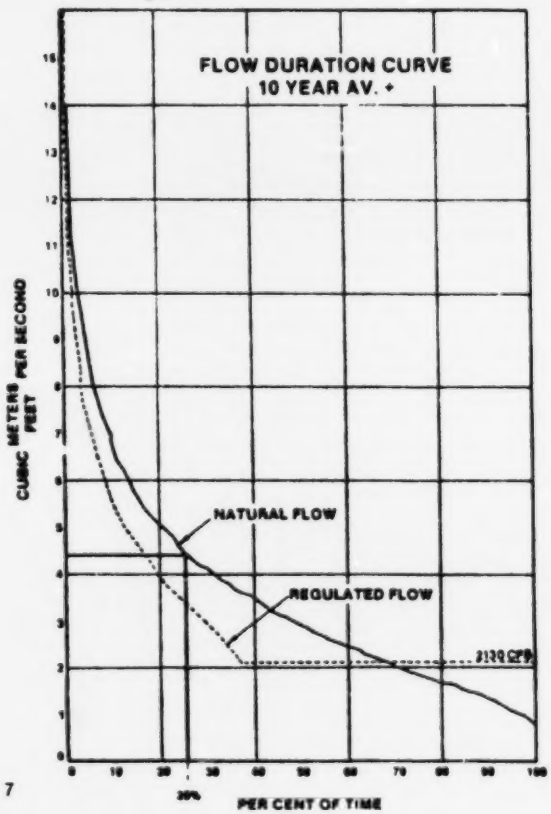
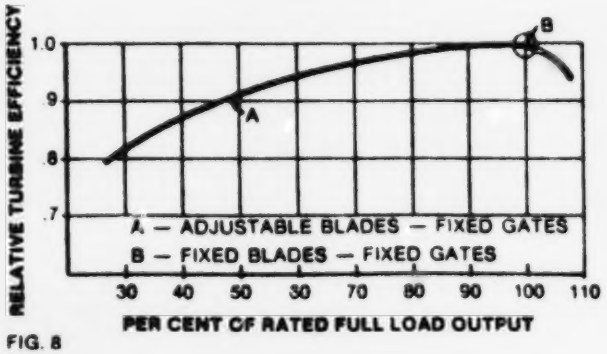


FIG. 7


RELATIVE TURBINE EFFICIENCY
A — ADJUSTABLE BLADES — FIXED GATES
B — FIXED BLADES — FIXED GATES
PER CENT OF RATED FULL LOAD OUTPUT
FIG. 8

The selection of hydraulic turbine type and size is primarily determined by the head and flow available at the particular site. The physical or structural strength of the turbine water passageways is determined by the maximum *gross head* (headwater elevation to tailwater elevation) plus pressure rise. Performance of the hydraulic turbine and the amount of power is determined by *net head* (H_n), which is the gross head less head losses in the system. These head losses include losses through the trash racks, intake, penstock friction, as well as any turns or changes in velocity and draft tube outlet losses. Such losses are generally calculated in order to arrive at the net effective head on the turbine at any particular load or turbine discharge.

The quantity of water available determines the turbine size, although this size is also influenced by other factors such as the location of the turbine runner with respect to tailwater elevations. The amount of water available in future months and years is generally predicted from stream gauging station records. Most rivers have excessive water available during floods and inadequate water during dry spells. This may be modified by upstream storage reservoirs or the flow may be completely regulated as would be the case with an irrigation discharge control check.

Based on head duration trends influenced by headwater and tailwater elevations and flow duration trends, alternative hydraulic turbine sizes can be evaluated using the kilowatt hour output, capacity value and firm energy. The kilowatt capacity at various flows and corresponding heads can be plotted against the percent of time during one year, the area under this curve within the turbine/generator capability represents kilowatt hours which have an energy value.

If the turbine discharge can be essentially constant, the turbine can be very much simplified and costs reduced by using fixed position runner blades. Typical applications include: (a) the maintenance of minimum stream flows, (b) peaking operations of the turbines or (c) multiple units providing incremental discharges.

Where flow control is necessary such as (a) at run-of-the river installations or (b) where it is economically justified by added kilowatt hour output, adjustable runner blades provide a wide range of good efficiency. For some applications, an improved kilowatt hour output can be provided by using turbines of two different sizes, so that the low flow discharges can be accommodated at higher efficiency.

When fixed blade propeller runners are used, the generator output and turbine discharge are established by the runner blade and intake vane angles. These are determined at the time of manufacture to obtain the required output at the specified head and speed conditions. Output will vary with changes in head.

Adjustable blade runners provide a controllable generator output and turbine discharge at added cost. Blades are hydraulically operated and may be controlled by speed, frequency, load or water level requirements.

Sizing Chart

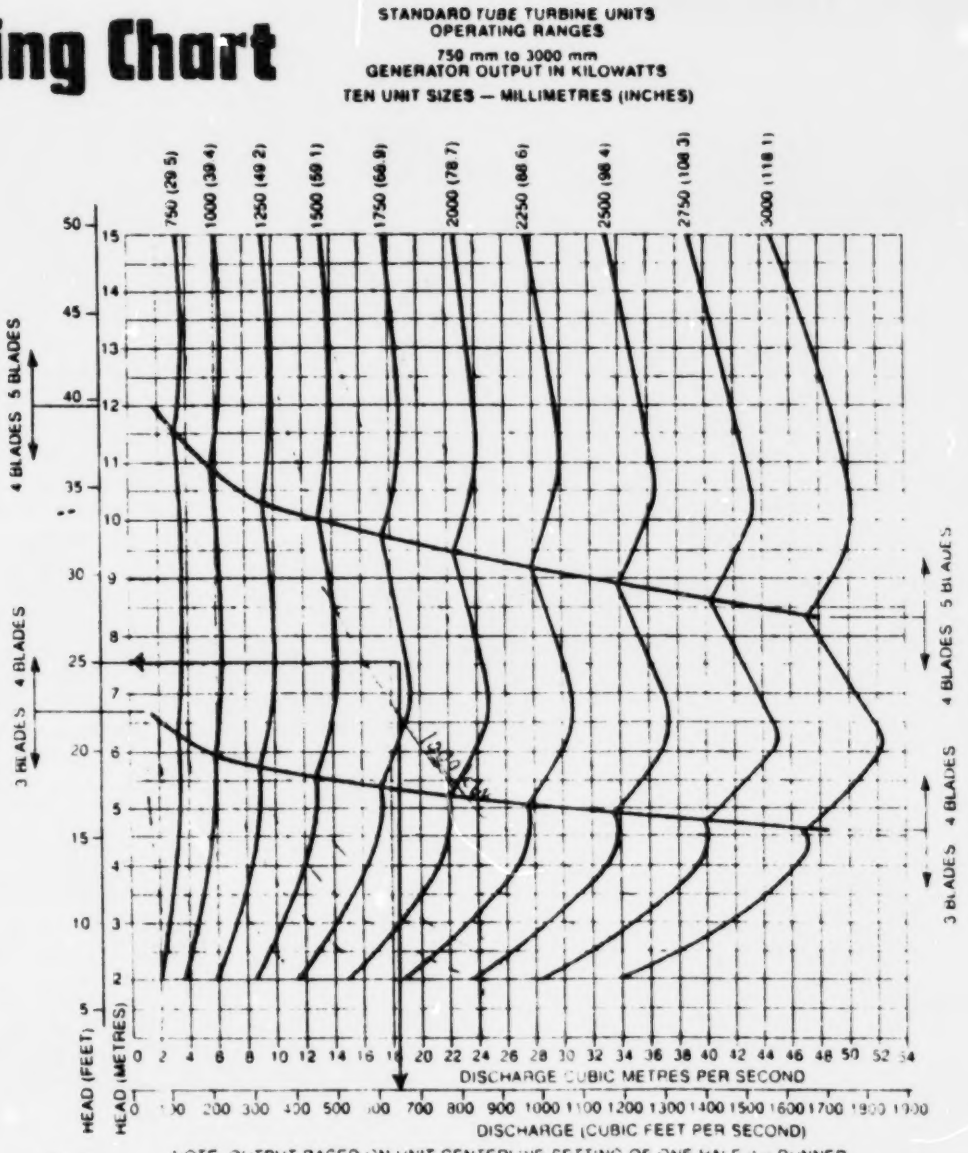


FIG. 9

NOTE OUTPUT BASED ON UNIT CENTERLINE SETTING OF ONE HALF (½) RUNNER DIAMETER (DIA./2) ABOVE TAILWATER CENTERLINE OF UNIT AT ELEVATION 150 m (500 ft.) ABOVE SEA LEVEL

[illegible] Operating [illegible] Chart Used.

Sea level site has 9 m head and a discharge of 48 m³/s. (Turbine shaft is located not more than 1.0 m above full load tailwater elevation. This height must be reduced by differences in vapor pressure due to altitude of turbine above sea level.)

1. Since 48 m³/s is beyond the sizing curve capacity at a 9 m head, at least two units are required; two at 24 m³/s were selected.
2. Intersection of 9 m and 24 m³/s is between 2000 and 2250 mm sizes and above 1500 KW.
3. A 2000 mm unit provides slightly less output and has a lower cost. Output at maximum blade angle is

$$\frac{23.0\ m^3/s}{20.0\ m^3/s} \times 1500\ KW = 1725\ KW$$

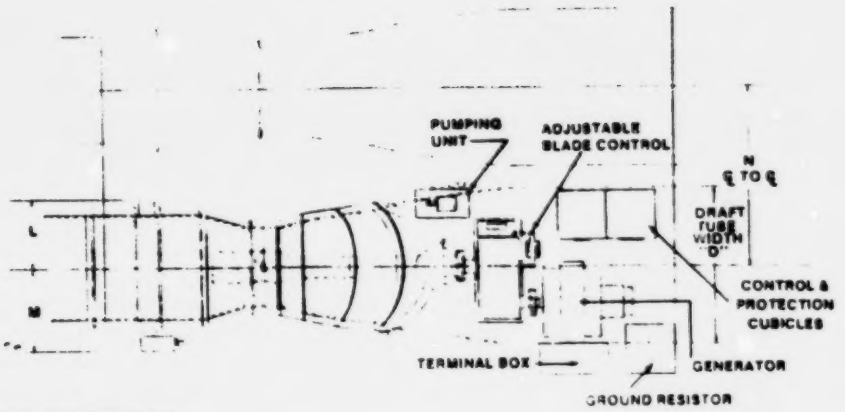
4. A 2250 mm unit provides a higher output at maximum blade angle and discharges the required amount of water at better efficiency. Output at maximum blade angle is

$$\frac{28.0\ m^3/s}{27.0\ m^3/s} \times 2000\ KW = 2074\ KW$$

Rated output is

$$\frac{24.0\ m^3/s}{28.0\ m^3/s} =$$

86% of full load and is therefore near best efficiency. A larger turbine will be required if the unit is located more than 1.1 m above tailwater elevation.



HORIZONTAL UNITS

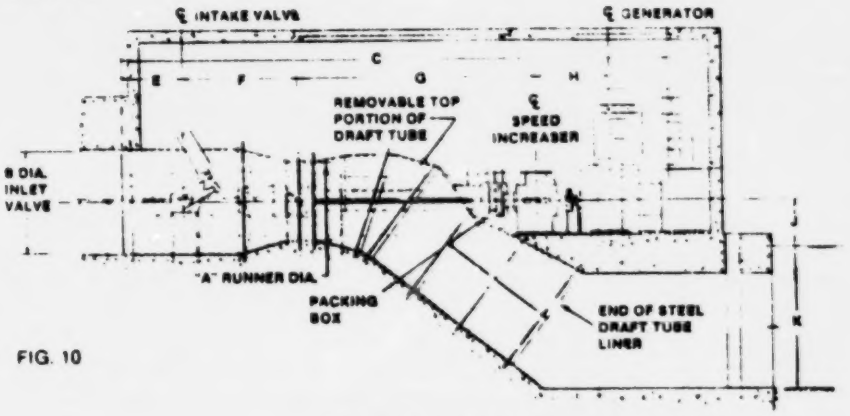


FIG. 10

BASIC DIMENSIONS

A = Runner Diameter in millimeters (inches) = 1.00

All Other Dimensions Are In Proportion From Runner Diameter

A	750 (29.5)	1000 (39.4)	1250 (49.2)	1500 (59.6)	1750 (68.9)	2000 (78.7)	2250 (88.6)	2500 (98.4)	2750 (108.3)	3000 (118.1)
B	1.43	1.37	1.34	1.32	1.31	1.30	1.29	1.28	1.27	1.22
C	8.6	7.9	7.3	7.2	6.9	6.7	6.6	6.6	6.5	6.5
D	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
E	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6
F	1.8	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4
G	3.8	3.6	3.5	3.5	3.4	3.4	3.3	3.3	3.3	3.3
H	1.5	1.3	1.1	1.1	1.0	0.9	0.9	0.9	0.8	0.8
J	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
K	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
L	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.7
M	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2
N	3.0	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.3	2.2

NOTE: Dimensions are approximate and may vary for specific applications.

Information required for the application and selection of hydraulic turbines

Our complete facilities are at the service of water power users. We provide recommendations, layouts and proposals for both new developments and the reconstructing of existing plants. However, proper selection and application requires detailed, specific information. To prepare a complete proposal promptly, it is important that the following data, where applicable and available, be sent with each inquiry.

Name, firm or corporation, with address.
Location and name of the plant.
Approximate elevation of the plant above sea level.
Total quantity of water in cubic feet or cubic meters per second; with comments regarding the variations in daily and seasonal flow, as well as storage capacity. Flow duration curves and drainage area.
Quality of the water. Does it contain sand, chemicals or other impurities?
Gross head (vertical distance from the headwater level to the tailwater level) with any known variations preferably correlated with flow.
If already determined, net or effective head on which all guarantees are to be based, with any known variations.
(If it has not been determined, we are prepared to estimate the net effective head based on the penstock or flume dimensions.)
Amount of power desired or required.

) Discharge or load at which maximum efficiency is desired.
Number and size of the units contemplated or required now and for future installation. If new units are to be sized for an existing plant, give space limitations and details of existing foundations and superstructure.
Distance from normal tailwater level to powerhouse floor, with variations and relation to flow.
Proposed length, diameter and material of the supply pipe (penstock) if required. If already designed or installed, give complete information.
If a surge tank is installed or contemplated on the pipeline, the distance along the penstock from the surge tank to the powerhouse and all available surge tank data.
Will the plant operate separately or in parallel with a power system? If in parallel, give approximate installed capacity of the system and its frequency.
Method of intended operation — manual, semi-automatic, fully automatic or remote control.
Supplementary information with drawings or sketches, to assist in proper interpretation of the data.

Since many dimensions may be changed before the plant is actually constructed, the purchaser must be responsible for the net effective head, the elevations of the head and tailwater levels, and the quantity of water, as well as the exactness of all field information on which the final design of the turbines is based.

The information contained herein is general in nature and is not intended for specific construction, installation, or application purposes. Allis-Chalmers reserves the right to make changes in specifications shown herein or add improvements at any time without notice or obligation.

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